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AUTHOR Richter, Winston
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ABSTRACT

Concern for the education of whole persons is not new in American higher education, but recent authors have expressed a new urgency for a return to a common core curriculum for general education. One model can be seen in the Miami-Dade General Education program, another in the human-value-orientation of Walter Lippincott, which is particularly relevant to the natural sciences component. Many authors point to the relationship between social needs and the type of curriculum and instruction that science educators are called upon to provide; future theorists attempt to provide a framework of predictions upon which planning to meet natural sciences educational needs can be based. From these predictions, five philosophical recommendations for natural sciences courses can be made: (1) a cross section of the diverse student population should make up each class; (2) class goals should include development of scientific literacy and the ability to analyze, understand, and integrate social issues; (3) the world should be presented as a system of integrated, interdependent subsystems, and emphasis should be placed on coping with rapid change and knowledge explosion; (4) the learning environment should subsume the entire community; and (5) students should develop skill in interpreting the labor market. The idea that a general education natural science course should address societal issues is not new; cogent arguments have been forwarded both for and against it. (AYC)

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General Education Natural Science
For a Changing Society
Quo Vadimus?

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Winston Richter
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General education is a major element (in this writer's view, perhaps "the" major element) of a complete education. Definitions of general education are legion (Scigliano & Scigliano, 1977, pp. 250-255), but for present purposes, the definition recently advanced by Miami-Dade Community College (1978) is both representative and enlightening:

General education . . . is that aspect of the . . . instructional program which has as its fundamental purpose the development and integration of every student's knowledge, skills, attitudes and experiences so that the student can engage effectively in a lifelong process of inquiry and decision making. The general education program provides the opportunity for students to acquire the knowledge, skills and attitudes that are fundamental to every individual's effort to have a more satisfactory life and to function as a more effective citizen. (p. 29)

Johnson (1952) provides specificity for the above mentioned "knowledge, skills, and attitudes" in a series of goals of general education.

The general education program aims to help each student increase his [her] competence in:

1. Exercising the privileges and responsibilities of democratic citizenship.
2. Developing a set of sound spiritual and moral values by which he [she] guides his [her] life.
3. Expressing his [her] thoughts clearly in speaking and writing, and in reading and listening with understanding.
4. Using the basic mathematical and mechanical skills necessary in everyday life.
5. Using methods of critical thinking for the solution of problems and for the discrimination among values.
6. Understanding his [her] cultural heritage so that he [she] may gain a perspective of his [her] time and place in the world.

7. Understanding his [her] interaction with [the] biological and physical environment so that he [she] may better adjust to and improve that environment.
8. Maintaining good mental and physical health for himself [herself], his [her] family, and his [her] community.
9. Developing a balanced personal and social adjustment.
10. Sharing in the development of a satisfactory home and family life.
11. Achieving a satisfactory vocational adjustment.
12. Taking part in some form of satisfying creative activity, and in appreciating the creative activities of others, (pp. 21-22)

Realization that these goals pre-date the MDCC definition by some twenty-six years, yet remain completely compatible and relevant, is evidence that concern for the education of whole persons is not new in American higher education. What perhaps is new is the "clear and explicit recognition . . . that students do not achieve [these goals] accidentally as a result of exposure to a random selection from the hundreds of available courses" (Thornton, 1972, p. 204).

Concrete action responding to the above mentioned "clear and explicit recognition" is an even newer phenomenon. As recently as 1976, an analysis (Hudson & Smith) of the general education program of the 103 California community colleges found:

1. that very few community colleges offer courses designed to achieve the purposes of general education but rather utilize existing transfer courses to introduce students to a field of study, trusting that the purposes of general education will be achieved in the process. (p. 59)
2. that the emphasis in general education is transfer . . . non-transfer students must enroll in transfer courses in order to meet general education requirements for graduation . . . general education programs are designed primarily to meet both the requirements of the student's major field and the general education requirements of the four-year institution (p. 60)

3. in view of all that is known about the number of students who transfer to four-year institutions, the utilization of transfer courses to meet general education requirements would seem unwarranted. (p. 61)
4. it appears that general education is "up for grabs" and that virtually any course is acceptable in some way . . . it can be said that for all practical purposes, general education has been rendered an ineffective part of the student's program. (pp. 61-62)

Ernest L. Boyer (Boyer & Kaplan, 1977), the new United States Commissioner of Education, expresses the urgency for a return to a common core curriculum for general education in the following compelling language:

Can the American Experiment survive . . . without exposing our people educationally to their common bonds? We believe that social survival in this and the next century is more likely when a common sharing of our human voyage is rediscovered by our educational leaders. We believe we are indeed in a race for social survival and that some return to a core of learning is crucial . . . Everything - the vanished consensus, the spread of knowledge, institutional inertia - argues against it. Yet while diversity necessarily and correctly affirms the individual, education for independence is not enough. Education for interdependence is just as vital. (p. 22)

A model for responding to this call can be seen in the currently developing Miami-Dade General Education Program which features a common core of five mutually supportive courses for all students. Tentative (providing description of emphasis only) titles for these courses are: Communications, Humanities, The Social Environment, The Natural Environment, and Individual Growth and Development. "The courses will be designed so as to stress their relationships and to assist students in the process of integrating their knowledge" (MDCC, 1978, p. 61).

The Setting:

Cogent enlightenment for educators embarking upon such a project comes from (perhaps to non-scientists) an unexpected source - the editor of the *Journal of Chemical Education*. Walter Lippincott (1977) submits that a substantial case is made by critics who characterize contemporary culture as "pursuing the goal of exploiting both nature and the mind in the service of efficient production, incessant consumption and sensate gratification . . . creating conditions in which the individual finds less and less need to understand anything beyond his own narrow sphere of specialization . . . and more and more opportunity to accommodate without question" (p.133). He lays blame for this condition at the feet of higher education; including in his indictment, the sciences, engineering, economics, but also the humanities and social sciences, for failing to balance specialized knowledge with "a humanizing and value-based education."

With encouragement to science teachers to adopt such a position, Lippincott characterizes humanists as searching:

not for final answers or final explanations, but for insights into the nature and potential of mankind, and into the significance and substance of qualities as dignity, justice, love, joy, and guilt. The aim is to enable the individual to recognize what is good and just and honorable, and to make choices accordingly. (p. 133)

Observing that the major problem faced by humanitists is the "sheer complexity of it all," Lippincott further observes that little help can be expected from the social sciences:

because of what appears to be an unmovable commitment to value-free knowledge . . . emphasis on empirical observation and techniques of measurement is accompanied by procedural canons that assiduously protect the study of fact from contamination by the value preferences of the observer. Much of this is an understandable over-reaction to harsh lessons learned in the past . . . such as recognition that . . . irreparable harm resulted from the failure of individuals and groups to distinguish what the world is really like from what they would have liked it to be. (p. 133)

With the observation that far too many phenomena of the social world encompass the realization of values for such an ethically detached approach to make significant contributions to a value-based education of students, Lippincott notes that from the beginning the natural sciences:

have looked, not toward man, but toward the structure of nature and the universe. Ironically perhaps, many of their advances have been so astounding, overwhelming, and unsettling that they have challenged traditional views of the nature and role of man. Moreover, the sciences are primarily problem-solving disciplines. They assume the problems they deal with have rational solutions arrived at by reducing each problem to a set of propositions. But surely there is more to man and life than a set of propositions, a propensity for problem-solving, or even a genius for understanding nature and interpreting the universe. (p. 61)
(underlining, mine)

In his truly moving conclusion, Lippincott lays down what, in the opinion of this writer, is the guiding principle for the development of a relevant general education core curriculum, and the natural science component thereof in particular:

Missing from the still unanswered hopes of the humanities, the moral relativism of the social sciences and the disquieting profundity of the natural sciences is the quality described as human feeling, taken in its most rational and normative sense. It is this that helps us to distinguish, and perhaps even to choose, right from wrong, good from bad, compassion from indifference, truth from error and justice from injustice . . . This image

[of man as a creature of extraordinary promise and worth] finds fulfillment and realization in all fields of knowledge and in all but the most base of human activities. The formulation of this image and its expression in human [values] is the most central of all questions of [general] education. (p. 61)

Probable Futures:

Following a concise but thorough review of the history of science education in America, Bybee (1977) concludes:

there is a clear relationship between social needs and the type of curriculum and instruction which science educators are called on to provide in the schools of this country. The major social pressures have been the early development of a nation; growth of an industrial-technological society; demands of a depressed economy; emergence of an atomic age; starting of the space race; and, the recent appearance of alienation and anxiety. Reform in science education is not new; we have been continually reforming for over 200 years. The process of reform takes place within our community of science educators but it seems clear from our history - reform is occasioned and directed by the larger social milieu within which we exist. (p. 341)

Based on this conclusion, it is natural to wonder what developments are likely in future society. Interest in what the future holds is surely as old as civilization itself; serious scientific effort to predict the future with confidence and reliability is a more recent phenomenon. Martino (1972, pp. 646-649) relates that formal futures research was initiated after WW II by the military, with the Navy leading the way in long range planning. By the 1950's, futures research had spilled over into the civilian sector, and Heinmiller (1977, p. 14) notes that by the 1960's, futurology had achieved academic status. The First Industrial Management Conference on Technological Forecasting was held in 1967.

Roy C. Amara (1974), President of the Institute for the Future lists the underlying assumptions implicit in prediction models:

1. The Future is neither entirely unforeseeable nor entirely inevitable.
2. There exist alternative futures - like alternative paths in some new and unexplored territory. Each path has some possibility of being chosen. Our job as futurists is to lay out these pathways for inspection and examination.
3. Choices can be made more intelligently by increasing our level of awareness of these alternatives and the consequences of choices among them.
4. Finally, and possibly most important, we can exercise some influence in making desirable futures more likely, and less desirable futures less likely.

Futures theorists hold that events that will occur between now and the year 2000 will be determined in large measure by decisions made now. "The evolution of the future is not a passive event, rather it is something we build through individual and collective decisions - through concrete application of our aspirations and dreams" (Fritsch, 1976, p. 26).

Several authors (Amara, 1974; Elliot, 1976; Evans, 1977; Fritsch, 1976; Shane, 1976; Sirkin, 1976) have gleaned from the burgeoning literature of futures theorists, predictions that may be of particular interest to science educators interested in gaining insight into future societal conditions that a general education science course may be called upon to address. As these summaries are themselves lengthy, and considerable overlap among them exists, there follows a further summary wherein the predictions are paraphrased and placed into useful order.

1. Political and economic power will increasingly be equalized between countries controlling technology and capital and those controlling scarce

resources.

2. The world's population will be dealing increasingly with uncertainties involving food, energy, pollution, and non-renewable resources.
3. A new concept of growth will become more widely accepted, one which achieves a better balance between social and economic concerns, and places greater emphasis on conservation, quality of life, limits, and recycling.
4. Emphasis within the economy will shift from large scale, capital-intensive, labor-saving technology toward economic designs characterized by smaller scale, labor intensive industries, with decreased emphasis on consumer products and increased emphasis on services to meet human needs.
5. The basic sciences will furnish the cornerstone of the post industrial age. In spite of this, society will require only a small cadre of highly specialized scientists . . . a generally low level of scientific literacy among citizens will increasingly exacerbate the "two culture" split noted by C. P. Snow.
6. Increased cognizance of human rights in technological decision making will be demanded by citizens.
7. Social and political tensions will continue to escalate.
8. The U. S. population will reach approximately 260 million and the world population will increase from 4 to 6 billion by the year 2000.
9. Shifts in the U. S. age distribution will result in most people being over 50 years of age.

10. Economic and political inequity between men and women will diminish, sex stereotyping in the job market will continue to diminish.
11. Obsolescence of skills caused by rapid changes in technology will cause many people to retrain frequently for second, third, . . . careers.
12. The "Protestant work ethic" will increasingly be challenged, workers will realize increasingly greater amounts of leisure (discretionary) time.
13. The effects of nutritional imbalance on learning disabilities and mental/ personality disorders will be increasingly understood. Personality modification through the use of psycho-active drugs will become feasible.
14. Universal access to higher education will be increasingly approximated in America.
15. Change will be ever more rapid, the knowledge explosion will escalate.
16. Rapid advance in computer technology coupled with the development of increasingly sophisticated methods of inquiry (e. g. systems analysis) will have the effect that:
 - (a) increasingly complicated problems will be subjected to quantitative investigation, and
 - (b) the classical technique of working out mathematically exact solutions to simplified approximations of intricate problems will be displaced by the direct analysis of organized complexity.
17. Proliferation of inexpensive, portable, electronic calculators will render mental arithmetic skills obsolete. Increasingly wide-spread personal

ownership of computers will have a similar effect on algebraic, trigonometric, and calculus skills.

18. Universal, exclusive use of the metric system will obtain.

Implications:

As suggested earlier, there is an important difference between passively predicting the future and planning it. Though the first is at least one step better than merely responding to crises as they occur, future planning suggests actively shaping what is to come. If the foregoing is an accurate sampling of likely future events - assuming humans choose not to try to alter them, or prove unable to - then it is within this context that natural science educators should decide on objectives and examine alternative strategies.

The designing of an optimum natural science educational experience for the future is no trivial undertaking. Indeed it is a weighty, and probably lengthy, project worthy of the best creative efforts of many talented science educators. The writer draws several inferences from the preceding predictions and these are offered as general philosophical recommendations rather than specific operational steps or a selection of subject matter.

1. Conscious effort should be made to insure that each class is populated by a representative cross section of the student body: university parallel (including pre-science majors), occupational education, continuing education, men and women, young and old, and minority. Rather than focus, as is traditional, upon young adults, the aim should be to exploit rather than bewail the diversity

found in community college classes and cause maximum interaction among individuals of different interests, abilities, ages, and achievement levels. Replacing the traditional lecture, should be a cooperative study which provides practice in techniques of negotiation and compromise and demonstrates the necessity for interdependence. Adopting the role of facilitator and resource person, the instructor should make conscious effort to dispell elitist attitudes ("the arrogance of the specialist") and to recognize the dignity of all points of view.

2. The overriding goal should be to educate thoughtful citizens who are able to analyze, understand and integrate social issues; who are prepared to participate in making sound and consistent democratic decisions. There should be a shift in emphasis from teaching science content to developing scientific literacy; from memorizing science content to locating and using it. Students should come to understand what are the possibilities of science and what are its limitations, what is confidently held by scientists and what is more tentative (what is the nature of theory), when may the citizen rely on expert advice and when is skepticism more appropriate - and how to look for bias and inconsistency in the latter case. A wide range of supported opinion should be sought and there should be ample opportunity for values clarification - students should be encouraged to begin making their own personal choices.

3. Students should begin to comprehend a model of the world as a system composed of interacting, interdependent subsystems, each having global impact. The environment is finite; students must become aware of the physical limitations

and ultimate carrying capacity of the earth system. The many contemporary crises - involving the physical variables of economics, population, and energy resources - are signals demanding a different rate and direction of growth. Salk (1973) and Kahn (1976) suggest the earth system is now at the point of inflection between an exponential growth curve and an inverse curve for future growth. Significantly, they posit that for human beings, the primary changes to take place at the point of inflection are in the realm of values.

Learning experiences should place emphasis upon techniques for dealing with whole problems; upon dealing with organized complexity instead of analyzing artificially separated parts of problems. Students should become acquainted with the notions of uncertainty and probability and should be given practical experience with methods of statistics. Above all, students should come to recognize the inevitability of, and begin to develop skills for coping with, continued rapid change and an unabating knowledge explosion.

4. The boundaries of the learning environment should be enlarged from the classroom to subsume the entire community. The classroom should be viewed as a learning center that provides social services to the community which, in turn, serves as a learning laboratory. Moreover it is proper to view the learning experience as a joint college-community enterprise and to make full utilization of such expertise as is available among citizens. Opportunity should be provided for informed and/or concerned citizens to address the class on appropriate societal issues. The teacher should strive to provide the widest possible range of learning options that is consistent with the cooperative nature

of the study. It should be possible for students to earn credit through work experience, service with civic action groups, and other appropriate out-of-class experience.

5. Students should develop skill in interpreting labor market information, especially that concerning science oriented and technical occupations. Market conditions (manpower needs) are influenced by national economic and political directions, and by shifts in social values and the availability of leisure time. Because of the trans-national character of much of American business and industry, further influence derives from shifts in the world-system economy stimulated by OPEC nations, Common Market countries, and by other nations that affect this nation's strategic interests.

The development of such learning skills as insure continued trainability is the best hedge against technological unemployment; students should avoid narrow specialization and recognize the necessity for periodic retraining, both on-the-job and in school. High priority should be given to career investigation which increases awareness of, and ascribes status to, the increasing number of paraprofessional and service oriented occupations. Women and minority students should be encouraged to broaden their career horizons to include scientific and technical opportunities. It is highly desirable that students be stimulated, by their initial exposures to scientific perspectives, to enlarge upon their acquired perspectives in further science courses. A possible indication of the relevance of the initial exposure may be the extent to which such occurs.

6. Selection of topics for study should reflect student interests as guided by the instructor. Since students are expected to integrate relevant information from a variety of disciplines, it is appropriate to expect the instructor to do no less. A team-teaching model would set a philosophically inconsistent example.

Contemporary Opinion:

That a general education natural science course may appropriately address societal issues is not an entirely new idea among science educators. Volume II of the Guide to Innovations in Physics Teaching (American Association of Physics Teachers, 1974) describes 50 such courses and lists 118 colleges and universities which offer physics courses with a societal theme. Heitowit (cited in Schroer, 1977a, p. 166) reports that 175 colleges and universities have formal programs which focus on the science and society interaction. A recent survey conducted for the Educational Testing Service on the Advanced Placement Program in Biology (Kormondy, 1976) found that from the group of colleges receiving the greatest number of requests for advanced placement in biology, 54 out of 64 offered special courses for the general education student. Kormondy further reports that the "majority of these courses have social immediacy and potential or actual applicability. Well-informed colleagues in engineering, physics, chemistry, earth sciences, psychology, and sociology relate that parallel curricular developments are taking place in those disciplines as well" (p. 94).

The results of a survey (Blatt, 1977) in which 83 of 93 schools, all accredited by the American Chemical Society, returned questionnaires showed the following:

1. 63% of the schools offer chemistry courses specifically designed for non-science majors . . .
2. Over half of all non-science majors courses originated between the years 1966 and 1975 with 1970 being the year in which there was the largest number of initiations . . .
3. Only 36% of respondents report that their courses were society oriented "to a great extent" . . .
4. Only 55% of respondents indicated that their method of instruction differed from the traditional lecture, laboratory, recitation mode. (p. 89)

This educational phenomenon has not met with universal approval.

Kormondy (1976) reports that "it is the common view of these college teachers (who teach courses that deal with social issues) that they would not have so acted ten to fifteen years earlier and that then it was decidedly neither incumbent upon them to do so nor was it professionally acceptable" (p. 94). Bybee (1977) adds that "a model of science teaching in which the primary aim is knowledge has dominated and continues to dominate our science programs. Models emphasizing the scientific method, problem solving, personal development, values, attitudes, and aesthetics have had only limited success " (p. 341).

The March, 1977, edition of the Physics Teacher contains a series of articles in which a debate on the worthiness of "Physics and Society" courses is conducted with Dr. Arnold Arons (past president of the American Association of Physics Teachers) taking the negative position, and Dr. Dietrich Schroeer (recipient of the 1972 American Institute of Physics/U. S. Steel Science Writing Award) taking the affirmative. A selection of their remarks is enlightening:

Intellectual (underlining, mine) integrity demands, however, that students develop some genuine comprehension of the scientific concepts, theories, and insights underlying these problems and not be encouraged to discourse vacuously on matter of which they have no understanding . . . I submit that these efforts will founder . . .

because . . . [the pace of such courses] precludes the development of any sense of how concepts and theories originate, how they come to be validated and accepted . . . (Arons, 1977, p. 168)

Social (underlining, mine) integrity requires a compromise between technical understanding and societal appreciation. A political scientist does not have to be a practicing politician, and a priest does not have to experience godhood - no matter how much that would enhance intellectual integrity. Similarly, to tell students about the norms of science it is not necessary to give them the experience of being scientists . . . It is too much to expect . . . politicians and the general public to understand "essential prior scientific concepts" concerning all the important social issues. (Schroeer, 1977b, p. 170)

I have still another reservation about . . . courses which contain essentially no science subject matter and deal with problems in the fields of political science, sociology, economics, etc.: Is the physicist who arrogates the right to teach this course professionally qualified to do so? If he is not so qualified, should he be doing the teaching? (Arons, 1977, p. 168)

Perhaps we should leave the discussion of such issues to the social scientists and to the humanists. Unfortunately we have so impressed these with the importance and the intellectual rigor of the hard sciences that they are afraid to try it. Perhaps the answer is that a teacher of P & S courses really does more guiding of discussions than transmittal of important facts. It may even do the students some good to meet a physics teacher who does not know everything. (Schroeer, 1977b, p. 170)

I heard . . . some plaintive queries about why the physics departments of the more "prestigious" colleges and universities did not embrace and offer "societal" courses of this kind, lending their sanction and support to the enterprise. It seems to me that the answer to this query is quite simple. In those institutions, prestigious by virtue of the professional quality and productivity of their faculties, physicists will simply not undertake to offer courses they are not qualified to teach. (Arons, 1977, p. 168)

That is nonsense. Faculty at such institutions do discuss social issues; but they do it as advisors to presidents rather than as discussion leaders for ordinary citizens. They recognize that discussions with average students do not lead to either recognition or influence. (Schroeer, 1977b, p. 170)

Summary and Conclusions:

That there are cogent (at least passionate) arguments for and against, and that much uncertainty remains should not obscure one overriding consideration. Scientists and scientific progress have increasingly come to be judged in the context of human values. Such judgments find their ultimate expression in the forming of public policy because it is during that process that the products of science and technology are integrated, or aligned, with human values. It is during that process that scientific and technological answers to questions of what can be done are judged in the context of what ought to be done.

The argument that science educators should not presume to teach what they do not know misses the point that no one knows the answers. What is proposed is not unlike a research project for which the teacher serves as principal investigator. Preoccupation with what should be taught overlooks the greater significance of what may be discovered in the course of the search. Whatever of available knowledge is significant for the inquiries to be made should be fully used, and much information will probably be acquired by the student. Nevertheless, the study is not directed finally toward the acquiring of knowledge. What is of eventual interest in any philosophical inquiry is a judgment regarding what is best by way of policy or practice, all things considered.

As the inquiry proceeds, it will probably appear that what students are getting from their study is primarily an increased awareness of the issues with which society, and especially American society is confronted. Secondly, students

will probably begin to learn something about how to conduct such an inquiry cooperatively, even when their initial views are in obvious conflict. Thirdly, each student will probably begin constructing and organizing into a consistent body, ideas, of a very general sort, which have arisen from the cooperative study.

Taking a cue from these probabilities, the goals which the principal investigator will set for his/her colleagues in such an introductory study are:

1. students should gain increased awareness of issues which confront them in a changing world,
2. students should gain discipline in the business of considering cooperatively matters upon which their initial viewpoints are in conflict and are of unequal sophistication,
3. students should begin the deliberate construction of a philosophy of values which they can hold in common with their colleagues, a working outlook, which as years pass, they can continuously correct and enlarge cooperatively with their peers.

In an introductory course, perhaps the first of these will outweigh the rest. Awareness of the deeper issues which confront humans, sensitiveness to the point of being able to formulate these for study - such is the beginning of wisdom.

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